BIOLOGICAL EVALUATION OF GYPSY MOTH

at

Cuyahoga Valley National Park

2000

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ABSTRACT

In the fall of 2000, personnel from Cuyahoga Valley National Park (CVNP) and the USDA Forest Service conducted a gypsy moth egg mass survey at CVNP. The purpose of this survey was to determine population densities inorder to assess the potential for defoliation and the need for treatment in 2001. Current populations are sufficient to cause moderate (31-60%) defoliation on approximately 350 acres in the Towpath Village area at CVNP in 2001. Treatment to prevent defoliation is recommended.

METHODS

The park was divided into 36 survey areas. These survey areas were determined based on the following criteria: having significant recreational resources; having experienced defoliation in 2000; and having received treatment in spring 2000. The survey area consisted of 8,349 acres. Only areas containing susceptible host tree species (primarily oaks) were included in the survey. The number of sample plots within each unit was based on the number of forested acres per survey area. A minimum of four plots was used and one additional plot added for every 25 acres of forested area within each designated survey area. A total of 410 survey plots were conducted throughout the park.

Within each area, gypsy moth survey plots were randomly selected based upon available host trees (mainly oaks), number of acres and uniformity between egg mass counts. At each survey point, a 1/40th acre fixed radius plot was established and the percent new (2000) egg masses determined. The plots consisted of a tally of all new (2000) egg masses observed on the overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by 40 to determine the number of egg masses per acre (Liebhold et al., 1994). The survey results were then averaged to estimate egg mass density.

Egg mass length was estimated by measuring 5 randomly selected egg masses in or near most of the plots to determine the overall “health” of the existing population and as a measure of egg mass fecundity. The average egg mass length (measured in millimeters) and egg mass density (egg masses per acre) were used to estimate defoliation potential (Liebhold et al., 1993).

RESULTS

The 36 survey areas are presented in Figure 1 and summarized in Table 1. Overall, average egg mass densities ranged from 0-1,529 egg masses per acre and averaged 78 egg masses per acre. Average egg mass lengths ranged from 15-42 mm and averaged 24 mm There was at least a 90% reduction in egg mass density from the 1999 levels in 33 of the 36 surveyed blocks. Only one block (Towpath Village, survey area #43, approximately 350 acres) contains egg mass densities sufficient to cause noticeable defoliation in 2001(Figure 2). Egg mass densities in the Towpath Village area average 1,529 egg masses per acre and ranged from 0-7,040 egg masses per acre. This is a 43% reduction in egg mass densities from the 1999 results of 2,680 egg masses per acre. The average egg mass length was 24 mm in 2000.

DISCUSSION

The basic guidelines used to evaluate the risk of defoliation include: previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food (mainly oaks); and risk of larval blow-in following egg hatch. Potential defoliation is categorized as: light (1-30 percent), moderate (31-60 percent), and heavy (61-100 percent).

Survey results indicate that the potential exists for moderate defoliation on approximately 350 acres at the Towpath Village area of the park in 2001 (Figure 3). Elsewhere in CVNP, noticeable defoliation is not likely to occur in the surveyed areas.

This conclusion is further supported when egg density is used as a means of predicting defoliation. Moore and Jones (1987) found that estimating the mean fecundity would increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity. Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (mm) and egg mass density provides a more precise means of estimating population densities and predicting defoliation. Using Liebhold's model, Figure 4 shows how this information can be used to correlate the predicted defoliation of an area. Accordingly, this translates to a projected defoliation level of approximately 44 percent at Towpath Village area. This represents an overall average and since egg mass densities and host type are not evenly distributed, actual defoliation will vary somewhat from tree to tree throughout the area.

The average egg mass length at Towpath Village area was 24 mm (Table 1). Egg masses larger than 25mm typically indicate healthy populations with no obvious stress from either the gypsy moth nucleopolyhedrosis virus (NPV) or the *Entomophaga maimaiga* fungus, two of the primary natural control agents that often express themselves in declining populations. Both of these entomopathogens were observed in gypsy moth caterpillar cadavers at the park in 2000. Decline in gypsy moth populations have occurred in both treated and untreated areas; indicating that there has been a general collapse of the gypsy moth population throughout much of the park and surrounding areas. Although it is still possible that either the gypsy moth fungus or the NPV could cause the general collapse of the gypsy moth population next year at Towpath Village area, it is difficult to determine if such a population collapse would occur prior to a significant defoliation event in 2001.

Predicting the extent of tree mortality that would occur after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. A more immediate and direct effect of defoliation is through the loss of oak mast. This occurs primarily from caterpillar feeding damage to flowers as well as foliage. Excessive foliage loss causes a lack of carbohydrates, which results in the abortion of immature acorns. It is possible to have several years of complete acorn failure during and the following years of moderate to heavy defoliation (Gottschalk, 1990).

In general, trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the following year, the impact is compounded. Trees that receive light-

moderate defoliation (< 60 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems.

Gypsy moth caused defoliation has been occurring in localized areas at CVNP at various intensities since 1996. In 2000, approximately 24 acres of moderate and 235 acres of heavy defoliation occurred on CVNP lands. Approximately 138 acres of the heavy defoliation and approximately 2 acres of the moderate defoliation occurred at the Towpath Village area. If these areas should be defoliated again in 2001, the potential for tree mortality increases.

The Allegheny National Forest (1988) and the West Virginia Division of Forestry (1997) provide examples of the potential tree mortality that can occur. On the Allegheny National Forest, untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28) percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In a 1986 study area in eastern West Virginia where oak species accounted for 63 to 78 percent of the species composition, a loss of 25 percent of the total oak sawtimber and 14 percent of the total oak poletimber occurred after one year of moderate to heavy defoliation. In these examples, droughty conditions likely contributed to the level of mortality.

In 2000, adequate rainfall occurred during the growing season in this portion of Ohio. This condition and the predicted level of moderate defoliation lessens the potential of tree mortality in the Towpath village area. However, it is impossible to predict drought conditions in 2001. If adequate rainfall is not received in 2001, and those areas that were heavily defoliated in 2000 are defoliated again in 2001, even though it may be moderate defoliation, the potential for tree mortality can increase due to these added stresses.

Management Options

For 2001, three management options have been evaluated for managing gypsy moth populations at CVNP. Resource managers at CVNP have previously determined that chemical insecticides will not be considered and therefore only microbial intervention tactics are presented. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage to prevent tree mortality; and 2) reduce gypsy moth population below the treatment thresholds. Ultimately, resource management objectives should dictate which option is desirable for managing gypsy moth populations within a given area. Each is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) or the more recently recognized fungal pathogen, *Entomophaga maimaiga*. In areas with defoliating level gypsy moth populations (greater than 750 egg masses per acre) viral epizootics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach defoliating levels and then collapse as a result of NPV or fungal activity. Residual populations

following such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels. Although it is possible that either the gypsy moth fungus or the NPV could cause a general collapse at the Towpath Village area, it is difficult to determine if the collapse would occur prior to a significant defoliation event in 2001.

Large numbers of gypsy moth caterpillars and defoliation have been shown to impact competing native herbivore arthropods. Sample et al. (1996) showed short-term impacts of both species richness and abundance occurred following light to moderate defoliation events in study plots in West Virginia. It is likely that impacts would be greater as the size of the area and intensity of defoliation increases and be more long term, should extensive tree mortality occur.

Should this option be selected, it is likely that some moderate defoliation will occur at CVNP in 2001.

Microbial Insecticide Option

Btk: The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringienis* variety *kurstaki (Btk).* This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *Btk* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *Btk* is persistent on foliage for about 7-10 days.

Btk has been shown to impact other non-target caterpillars that are exposed to the treatment and are actively feeding. An example of the potential impacts is provided by a study conducted by Miller (1990) in Oregon and Samples, et al. (1996) in West Virginia. Miller's study involved a large-scale eradication program where three consecutive applications of *Btk* were applied within a single season. On Garry oak, Miller found that species richness was significantly reduced in treated areas during all 3 years of the study while the total number of immature native Lepidoptera rebounded after the second year. In the Sample study, the areas treated with *Btk* were 50 acre plots and only a single treatment applied. Here too, both species richness and the total numbers of native macro-lepidopterous caterpillars and adults were reduced but only for less than 1-year. The difference in duration of the impacts between these studies is probably the result of the number of treatment applications applied and the size of the treatment area involved.

Btk formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double application. *Btk* can be applied either undiluted or mixed with water for a total volume of ½-1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely. Because *Btk* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek: A second microbial insecticide that is registered and available in limited quantities is the formulated nucleopolyhedrosis virus called Gypchek. This product is not available commercially but is produced in limited quantities by a cooperative effort of the USDA Forest

Service and the Animal Plant Health Inspection Service (APHIS). The active ingredient in Gypchek formulations has a very narrow host range (lymnatriids) and occurs naturally in gypsy moth populations. Normally the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations. The application of Gypchek to gypsy moth populations simply expedites this process by increasing the exposure of the virus at an earlier stage. Healthy, feeding gypsy moth caterpillars become infected by ingesting contaminated foliage and soon stop feeding and die.

The efficacy of Gypchek treatments to reduce gypsy moth populations has been quite variable. Because of the short period of viral activity on foliage (3-5 days) as well as other biological factors such as feeding activity and weather conditions, it has been difficult at best to project treatment efficacy. Most often foliage protection can be achieved but significant reductions in gypsy moth densities do not always occur. Should inadequate population reduction occur, areas would need to be treated again the following year.

The normal application rate of Gypchek is 2×10^{11} occlusion bodies (OB's) per acre applied in two applications, 3-5 days apart. Due to the limited supply, priority is first given to state and federal cooperators that need to deal with federally listed threatened and endangered species associated with gypsy moth treatments.

Alternatives

With the previously described options in mind, the following alternatives are offered.

Alternative 1. -No action

Alternative 2. -One aerial application of *Btk* at the rate of 36 BIUs in a total mix of ¾ gallon per acre.

Alternative 3 -Two aerial applications of Gypchek at the rate of 2×10^{11} OB's in a total mix of 1 gallon per acre, applied 3-5 days apart.

RECOMMENDATIONS

An integrated approach to managing gypsy moth populations is recommended and takes into account park management objectives, pest population densities, projected damage and the consequences of doing nothing. Moderate defoliation is predicted at the Towpath Village area at CVNP. If this level of defoliation and possible tree mortality conflicts with park management objectives, our recommendation is to aerially treat 350 acres at the Towpath Village area as described in either alternative 2 or 3.

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Table 1.—Fall 2000 Gypsy Moth Egg Mass Survey Results at Cuyahoga Valley National Park.

Survey Area	Area Name	Acres	2000 EM/Acre	1999 EM/Acre	% Change	2000 Avg. EM Length (mm)	2000 # of Plots	2000 (1) Treatment	2000 Defoliation
2	Republic Steel	59	56	4351	-99	15	5	--	Y
3	Canal CV	218	120	1570	-92	21	9	--	Y
4	Terra Vista	183	122	1068	-89	25	10	--	Y
8	Chaffee	294	4	5513	-100	27	10	A	--
10	Carriage Trail	680	0	8084	-100	--	30	A	--
11	Snowville/ Columbia	404	0	4910	-100	--	19	A	--
13	Buckeye Trail	108	0	4703	-100	--	6	A	--
14	Blue Hen Falls	187	0	2560	-100	--	10	A	Y
15	Between the Highways	73	0	2520	-100	--	6	--	Y
18	Oak Hill	690	104	7739	-99	--	30	P	Y
19	Furnace Run N	127	12	8066	-100	28	8	P	Y
24	Oneil woods	266	126	1408	-91	29	13	B	Y
25	Indian Mound	45	0	0	NA	--	4	--	--
26	Dorms	119	11	129	-91	23	7	B	Y
27	Brandywine	277	0	3998	-100	--	14	P	--
28	Stanford	130	32	4130	-99	--	8	P	--
29	Krecji N	256	34	11331	-100	--	13	P	Y
30	Krecji S	352	0	9707	-100	--	17	P	Y
31	A-P/Boston Mills	182	0	8527	-100	--	10	P	--
32	Pine Lane S	117	12	10641	-100	15	7	P	--
33	Boston Run	246	15	925	-98	--	8	P	--
34	Happy Days/Ledges	653	1	1156	-100	20	29	A	--
35	VK Lake	388	0	4004	-100	--	19	A	--
36	Quick S	124	129	1329	-90	26	8	A	Y
37	Wetmore N	120	0	2614	-100	--	8	P	--
39	Armington	139	126	5900	-98	21	8	P	--
43	Towpath Village	350	1529	2680	-43	24	17	B	Y
47	Salt Run	212	0	12894	-100	--	4	A	--
48	EEC	260	9	8729	-100	20	13	A	Y
49	Pine Lane N	296	0	2894	-100	--	14	P	--
53	Indigo Lake	41	0	2185	-100	--	4	A	--
55	Furnace Run S	267	83	8729	-99	--	13	P	Y
59	Riding Run	118	127	1952	-93	--	7	B	Y
62	Revere/Wheatley	61	146	1952	-92	42	5	P	--
63	Lock 29	145	5	2894	-100	25	8	P	--
68	Wetmore S	163	0	10513	-100	--	9	A	--

(1). Treatments in 2000 (A = all areas treated, P = partial treatment, B = buffer area to private lands only).